



IRON AND STEEL BYPRODUCTS



Resource efficiency means using fewer virgin raw materials. Increasingly, cement plants are turning to industrial byproducts and materials that otherwise would be discarded as sources for the basic elements needed for cement making.

After completing detailed analyses on their chemical characteristics to determine the effect on process chemistry and facility emissions, **many cement plants can utilize byproducts from the iron and steel industries as a raw material** in the manufacture of the clinker—the intermediate product in the process—or as an ingredient in the final cement product. | [more](#)

IRON AND STEEL BYPRODUCTS

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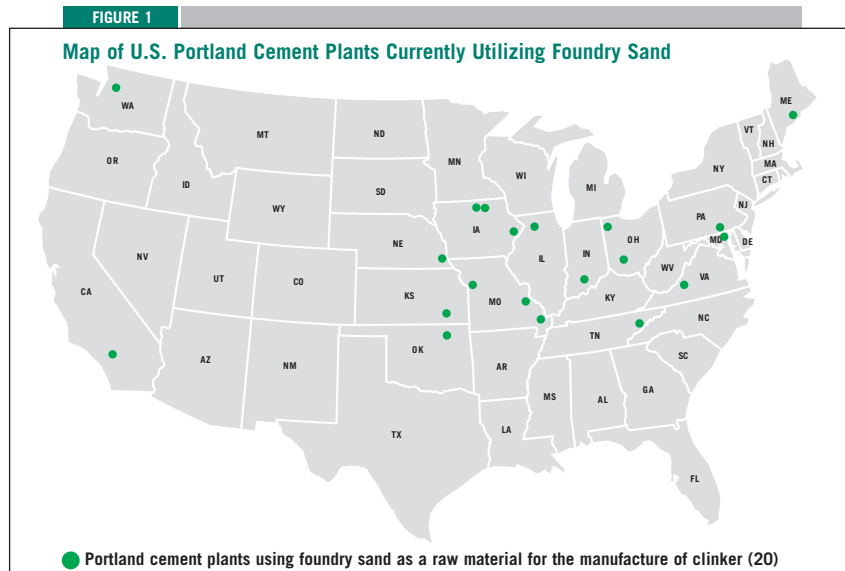
Three byproducts of the iron and steel industries can be used in the manufacture of portland cement: foundry sand, mill scale, and slag.

Foundry sand can provide silica and possibly iron for the production of clinker. Mill scale contains iron oxides that can replace other iron-bearing materials in the kiln feed. Slag contains high percentages of calcium oxide and silicon dioxide and varying amounts of aluminum oxide and iron oxides. All of these components are needed in the cement manufacturing process. Select slags can be interground with the portland cement to produce a blended cement product. Foundry sand and some slags can replace natural stone as an aggregate in portland cement concrete. Nearly 70% of U.S. portland cement plants use one or more of these byproducts to produce clinker or cement.

Foundry Sand

Foundry sand forms the mold into which molten metal is poured for casting iron, steel, and other metal components. After multiple uses, this high-quality silica sand degrades and is no longer used. In the United States, there are approximately 3,000 foundries that produce collectively 6 to 10 million short tons of foundry sand per year [FHWA 2004]. Because used foundry sand may contain trace amounts of metals from the castings, chemical binders used in shaping the molds, and other impurities, portland cement plants carefully analyze and monitor the foundry sands they use.

It is unknown how much foundry sand is used by the portland cement industry, but in 2005, 20 plants were using it as a raw material in the manufacture of clinker (as shown on Figure 1).



Mill Scale

During the processing of steel, iron oxides will form on the surface of the metal. These oxides, known as mill scale, occur during continuous casting, reheating, and hot rolling operations. The scale is removed by water sprays and often recycled by the steel plant. Mill scale that cannot be recycled by steel plants has been used by portland cement plants as an iron source.

Although the total amount of mill scale used by portland cement plants is unknown, in 2005, 51 plants were using it as a raw material in the manufacture of clinker (Figure 2).

Slag

There are two major types of slag: blast furnace slag and steel furnace slag. Blast furnace slag is a byproduct from the smelting of iron ore or iron pellets with coke and a flux, such as limestone or dolomite. The calcium in the stone combines with the aluminates and silicates in the ore and ash from the coke to produce this non-metallic material [NSA undated]. The slag is removed

THE CEMENT-MAKING PROCESS

Portland cement manufacturing is a four-step process:

1. Raw materials, including limestone and small amounts of sand and clay, come from a quarry usually located near the cement manufacturing plant. Limestone is typically about 80% of the raw mix and is the primary source of calcium. The remaining raw materials provide the silica and the necessary small amounts of alumina and iron.
2. The materials are carefully analyzed, precisely combined and blended, and then ground for further processing. This is called kiln feed.
3. The ground materials are heated in an industrial furnace, called a kiln, that reaches gas temperatures of 1,870°C (3,400°F). The heat causes the kiln feed to turn into a new substance called clinker. The kiln flame is fueled by powdered coal, powdered petroleum coke, natural gas, oil, and/or recycled materials burned for energy recovery.
4. Red-hot clinker is cooled and ground with a small amount of gypsum and typically other mineral components. The end result is a fine, gray-colored powder called portland cement.

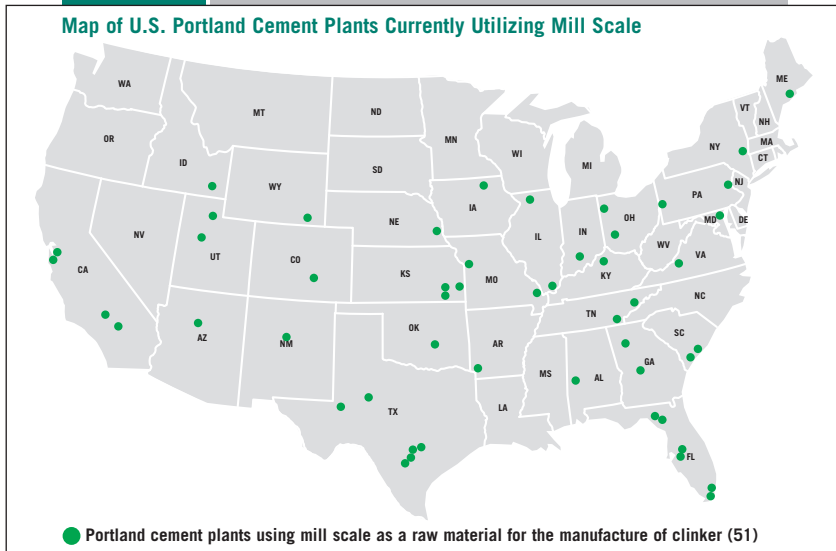
At each stage, process data are continuously monitored to produce a high-quality product, improve energy efficiency, and minimize emissions.

CEMENT OR CONCRETE?

The terms cement and concrete are often misused. Cement is an ingredient of concrete. It is the fine gray powder that, when mixed with water, sand, and gravel or crushed stone, forms the rock-like mass known as concrete. Cement acts as the binding agent or glue.

FIGURE 2

Map of U.S. Portland Cement Plants Currently Utilizing Mill Scale



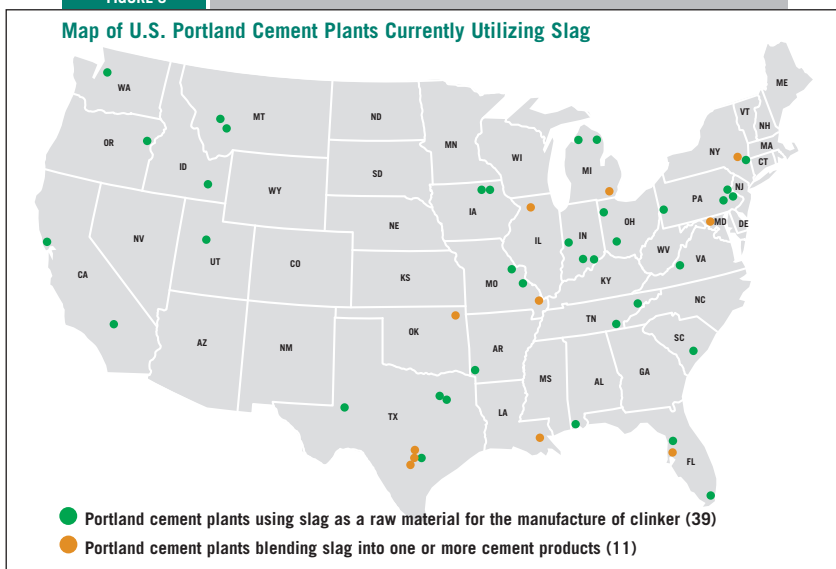
from the furnace for further processing. Blast furnace slag can be used in the production of clinker, blended cements, and/or as an aggregate in portland cement concrete.

Steel slag is a byproduct from the processing of iron or scrap steel in a basic oxygen furnace or electric arc furnace. Once again, limestone or dolomite is used as a flux to remove impurities [NSA undated]. The steel furnace slag is air cooled, and after free iron products are removed, it can be used as a raw material in the manufacture of clinker [NSA undated]. For 2003, the United States Geographical Survey estimated that 8.8 million metric tons of steel furnace slag was produced, and that over 5% of it was used by cement plants to produce clinker [USGS 2003].

In 2005, 39 portland cement plants were using slag as a raw material in the manufacture of clinker, and 11 plants were blending it into one or more cement products. (Figure 3 shows the locations of the plants utilizing slag.) | [more](#)

FIGURE 3

Map of U.S. Portland Cement Plants Currently Utilizing Slag



FOUNDRY SAND



MILL SCALE



SLAG

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Types of Blast Furnace Slags

Blast furnace slag is processed in one of the following methods:

- Air-cooled slag is allowed to cool slowly in ambient air. It can be used in the kiln feed or as an aggregate in concrete products [NSA undated]. Of the 7.3 million metric tons of air-cooled slag produced in the U.S. in 2003, nearly 16% was used in concrete products and nearly 6% in clinker production [USGS 2003].
- Expanded slag is cooled by a controlled quantity of water to produce a low density material. It is used as an aggregate in medium to light-weight ready-mixed concrete products. The USGS does not report the production or final use of it [USGS, 2003].
- Pelletized slag is cooled by water on a vibrating plate, which produces a foam-like material that is further processed into pellets. It can also be used as an aggregate in medium to light-weight ready-mixed concrete materials, or if finely ground, can be used in blended portland cements [NSA undated]. The USGS does not report the production or final use of pelletized slag [USGS 2003].
- Granulated slag is cooled rapidly by jets of water in direct contact with the molten material. This is the most common slag used in the production of blended portland cements [NSA Undated]. For 2003, the USGS estimated that 3.6 million metric tons of ground granulated blast furnace slag (GGBFS) was produced and the majority used in cement [USGS 2003].

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Portland Cement Association is a trade association representing cement companies in the United States and Canada. PCA's U.S. membership consists of 46 companies operating 102 plants in 36 states. PCA members account for more than 97% of cement-making capacity in the United States and 100% in Canada.

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